Berman, A. (Lockheed-Martin)

NASA SCIENTIFIC AND TECHNICAL DOCUMENT AVAILABILITY AUTHORIZATION (DAA)

To be initiated by the responsible NASA Project Officer, Technical Monitor, or other appropriate NASA official for all presentations, reports, papers, and proceedings that contain scientific and technical information. Explanations are on the back of this form and are presented in greater detail in NHB 2200.2, "NASA Scientific and Technical Information Handbook."

☐ Original
☐ Modified

(Facility Use Only)
Control No. G-1476
Date 2/20/96

I. DOCUMENT/PROJECT IDENTIFICATION (Information contained on report documentation page should not be repeated except title, date and contract number)

Title: Initial Usability Testing of a Hand-held Electronic Logbook for the Human Research Facility.

Author(s): A. H. Berman and M. Whitmore - LMES

Originating NASA Organization: Flight Crew Support Division - JSC

Performing Organization (if different) Lockheed-Martin Engineering & Sciences Services, Houston, Texas

Contract/Grant/Interagency/Project Number(s) NAS9-18800

Document Number(s) ~~LM31992, NASA # is T.B.D.~~ NASA CR-199849 Document Date: April 1996

(For presentations or externally published documents, enter appropriate information on the intended publication such as name, place, and date of conference, periodical or journal title, or book title and publisher: NASA ~~Technical/Paper~~ Contractor Report

These documents must be routed to NASA Headquarters, International Affairs Division for approval. (See Section VII))

II. AVAILABILITY CATEGORY

Check the appropriate category(ies):

Security Classification: ☐ Secret ☐ Secret RD ☐ Confidential ☐ Confidential RD ☒ Unclassified

Export Controlled Document - Documents marked in this block must be routed to NASA Headquarters International Affairs Division for approval.

☐ ITAR ☐ EAR

NASA Restricted Distribution Document

☐ FEDD ☐ Limited Distribution ☐ Special Conditions-See Section III

Document disclosing an invention

☐ Documents marked in this block must be withheld from release until six months have elapsed after submission of this form, unless a different release date is established by the appropriate counsel. (See Section IX).

Publicly Available Document

☒ Publicly available documents must be unclassified and may not be export-controlled or restricted distribution documents.

☐ Copyrighted ☐ Not copyrighted

III. SPECIAL CONDITIONS

Check one or more of the applicable boxes in each of (a) and (b) as the basis for special restricted distribution if the "Special Conditions" box under NASA Restricted Distribution Document in Section II is checked. Guidelines are provided on reverse side of form.

a. This document contains:

☐ Foreign government information ☐ Commercial product test or evaluation results ☐ Preliminary information ☐ Information subject to special contract provision

☐ Other—Specify

b. Check one of the following limitations as appropriate:

☐ U.S. Government agencies and U.S. Government agency contractors only ☐ NASA contractors and U.S. Government agencies only ☐ U.S. Government agencies only

☐ NASA personnel and NASA contractors only ☐ NASA personnel only ☐ Available only with approval of issuing office;

IV. BLANKET RELEASE (OPTIONAL)

All documents issued under the following contract/grant/project number ______ may be processed as checked in Sections II and III.

The blanket release authorization granted ______ (Date) is:

☐ Rescinded - Future documents must have individual availability authorizations.

☐ Modified - Limitations for all documents processed in the STI system under the blanket release should be changed to conform to blocks as checked in Section II.

V. PROJECT OFFICER/TECHNICAL MONITOR

J. L. Ellis — Typed Name of Project Officer/Technical Monitor
SP — Office Code
Signature
1/24/96 — Date

VI. PROGRAM OFFICE REVIEW ☐ Approved ☐ Not Approved

Typed Name of Program Office Representative
SA — Program Office and Code
Signature
1/29/96 — Date

VII. INTERNATIONAL AFFAIRS DIVISION REVIEW

☐ Open, domestic conference presentation approved. ☐ Export controlled limitation is not applicable.

☐ Foreign publication/presentation approved. ☐ The following Export controlled limitation (ITAR/EAR) is assigned to this document:

☐ Export controlled limitation is approved.

International Affairs Div. Representative — Title — Date

VIII. EXPIRATION OF REVIEW TIME

The document is being released in accordance with the availability category and limitation checked in Section II since no objection was received from the Program Office within 20 days of submission, as specified by NHB 2200.2, and approval by the International Affairs Division is not required.

Name & Title ______ Office Code ______ Date ______

Note: This release procedure cannot be used with documents designated as Export Controlled Documents, conference presentations or foreign publications.

IX. DOCUMENTS DISCLOSING AN INVENTION N/A

a. This document may be released on 2/15/96 (Date) Installation Patent or Intellectual Property Counsel Sandra G. Griffin Date 2/15/96

b. The document was processed on ______ (Date) in accordance with Sections II and III as applicable. NASA STI Facility ______ Date

X. DISPOSITION

Completed forms should be forwarded to the **NASA Scientific and Technical Information Facility, P.O. Box 8757, B.W.I. Airport, Maryland 21240**, with either (check box):

☐ Printed or reproducible copy of document enclosed

☐ Abstract or Report Documentation Page enclosed. The issuing or sponsoring NASA installation should provide a copy of the document, when complete, to the NASA Scientific and Technical Information Facility at the above listed address.

FF427 REV OCT86

CR-199849

NASA Contractor Report

Initial Usability Testing of a Hand-held Electronic Logbook Prototype for the Human Research Facility

Andrea H. Berman and Mihriban Whitmore

Contract NAS9-18800

April 1996

LM31992

Table of Contents

Acronyms

DSO	Detailed Supplemental Objective
HRF	Human Research Facility
ISS	International Space Station
LCD	Liquid Crystal Display
PDA	Personal Digital Assistant

Acknowledgements

This research was supported by Contract Number 0595-01390 from the National Aeronautics and Space Administration and conducted at the Johnson Space Center in Houston, Texas. The authors wish to thank Paul Campbell of Lockheed Martin Engineering & Science Services (LMESS) for providing hardware. Thanks are also extended to Carlos Sampaio and Melva Dobbins of LMESS and to Janella Youmans of McDonnell Douglas for participating in this experiment, as well as Lynette Bryan at Krug and Linda Billica and Bob Williams of the Reduced Gravity Office for assistance in preparing for and scheduling the KC-135 flights. A final thanks goes to the LMESS Technical Publications group for their help in touching up and printing a video frame capture for this paper.

Abstract

The Apple® Newton™ MessagePad 110 was flown aboard the KC-135 reduced gravity aircraft for microgravity usability testing. The Newton served as the initial hand-held electronic logbook prototype for the International Space Station (ISS) Human Research Facility (HRF). Subjects performed three different tasks with the Newton: 1) using the stylus to tap on different sections of the screen in order to launch an application and to select options within it; 2) using the stylus to write, and; 3) correcting handwriting recognition errors in a handwriting-intensive application. Subjects rated handwriting in microgravity "Borderline" and had great difficulties finding a way in which to adequately restrain themselves at the lower body in order to have their hands free for the Newton. Handwriting recognition was rated "Unacceptable," but this issue is hardware-related and not unique to the microgravity environment. It is suggested that the restraint and handwriting issues are related and require further joint research with the current Hand-held Electronic Logbook prototype: the Norand Pen*key Model #6300.

1.0 PURPOSE

The current International Space Station (ISS) configuration includes a four-rack suite of experimental hardware entitled the Human Research Facility (HRF). The purpose of the HRF is to provide laboratory equipment necessary to carry out multi-disciplinary basic, applied, and operational research on the ISS crewmembers in orbit. The six disciplines encompassed by the HRF are as follows:

1. Cardiopulmonary Physiology
2. Human Factors
3. Neuroscience
4. Musculoskeletal Physiology
5. Regulatory and Integrative Physiology
6. Environmental Health

(HRF Level 1 Science and Technical Requirements, p. 3)

The Crew Station Branch within the Flight Crew Support Division (FCSD) of NASA's Johnson Space Center was asked to develop the functional requirements for HRF hardware to be utilized in Human Factors research. One of these pieces of equipment is the Hand-held Electronic Logbook.

The logbook will be used to provide convenient recording of various types of biological data, to take notes (experiment-related and personal), to answer questionnaires (e.g., personality inventories and mood scales) and to view check-off lists and electronic procedures. It is currently planned that crewmembers will wear the logbooks on a belt or clipped to a hip pocket at all times (HRF Functional Requirements Document, p. 31). A rough prototype already procured by the FCSD, meeting many of the developed list of functional requirements, is the Apple® Newton™ MessagePad 110. Newton is a hand-held Personal Digital Assistant (PDA) with limited handwriting recognition capability. Inputs are made with a stylus by tapping or by handwriting on the liquid crystal display (LCD) screen. Table 1 outlines the HRF functional requirements for the logbook (HRF Functional Requirements Document, pp. 31-33).

The Human Factors and Ergonomics Laboratory within the Crew Station Branch evaluated basic logbook functions in microgravity during usability testing of the Apple Newton aboard the KC-135 reduced gravity aircraft. The primary objectives of this testing were twofold: 1) to identify potential problem areas in logbook design when utilized in microgravity, and 2) to gain an understanding of which areas of evaluation - whether unique to the microgravity environment or not - will require further investigation during later usability testing of logbook prototypes.

TABLE 1. HRF Functional Requirements Met by the Apple® Newton™

HRF Functional Requirement	Met by Newton? √ = Met √- = Partially Met
Being comfortably body worn	√
Providing complete alphanumeric entry capabilities	√
Displaying monochrome or color images and text	√
Scrolling backward and forward through the record for editing, review, or error correction	√
Providing a user friendly, interactive environment	√
Using disposable and rechargeable battery packs	√
Accommodating data transfer to and from other HRF computers	√-
Providing multiple PCMCIA slots and accompanying accessories: hard drive, memory expansion, barcode scanning, voice input/output	√-
Utilizing off-the-shelf applications as well as custom applications	√
Providing stylus or finger touch screen input	√
Providing wireless data exchange	√
Providing removable storage media for each crew member's personal use	√

2.0 METHOD

The following methods were employed in this evaluation.

2.1 Subjects. Three subjects participated in this evaluation. All were employees of contracting organizations with NASA Johnson Space Center.

2.2 Procedures. This usability evaluation was performed in conjunction with another evaluation aboard the KC-135. During microgravity parabolas in which subjects were not occupied with the primary evaluation, they were asked to perform three basic tasks with the Newton. Two Newton applications were used. Hippocrates®, the first application, covered two of the three basic tasks: 1) using the stylus to tap on different sections of the screen in order to launch the application and to select options within it, and 2) using the stylus to write. The second application, Newton's built-in address book, was used to evaluate the third task, namely, correcting handwriting recognition errors in a handwriting-intensive application. Subjects were given a brief tutorial in handwriting recognition, stylus usage, and the logical flow of Newton's screens prior to flight. Detailed procedures were provided for quick reference during the flights.

A demonstration version of Hippocrates - a patient information organizer for doctors - was used to develop a method by which the user could record the primary evaluation subjects' subjective physical exertion ratings after each microgravity parabola without the need of specifically programming a new application for Newton. Newton's built-in notepad gives the user the option of having Newton attempt to recognize handwriting, but the information is only saved as a dated notepad file. A unique feature of Hippocrates' notepad is that it does not attempt to recognize handwriting and allows the user to save the screen under any filename. For this task, a table template was created on the Hippocrates notepad display prior to flight, and the user recorded exertion ratings for 10 parabolas at a time on one file. This capability was originally developed to

diagram a patient's illness and to save the diagram in the patient's file, yet it lent itself to our needs quite well.

The subjects accomplished the third task, correcting handwriting recognition errors in a handwriting-intensive application, by using Newton's built-in address book. The Newton has the ability to 'learn' a person's handwriting style over time. Moreover, it allows users to specify their handwriting style by checking off statements such as, "I write with my letters widely spaced" and also allows the user to select which ways they print or write each letter of the alphabet, increasing the probability of Newton correctly recognizing their handwriting. Due to time and hardware constraints, the subjects did not have an opportunity to train Newton on their handwriting styles prior to flight.

Subjects filled out a post-flight questionnaire rating the PDA. A copy of the questionnaire is included in the Appendix.

3.0 RESULTS

Due to unforeseen time constraints during the flight, fewer subjects were dedicated to the PDA tasks than expected, and those subjects who did have time to evaluate Newton did not have much time to dedicate to performing the specific tasks as outlined above. It was hoped that one method of analysis for this study would be to analyze the data each subject entered into Newton and to record how much progress each subject made with the tasks.

Unfortunately, there is barely any objective data on the Newton from this study. There is a possible explanation for the lack of data from the first task. Each time information is added to the table of exertion ratings, the user must save the screen before exiting it in order to save the changes; the experimenters were careful to stress this fact during pre-flight briefings. The subjects stated they did indeed perform this task, but there is no data saved on the PDA with which to analyze their success. One major design problem with this software demonstration is that the user is not prompted to save the screen before exiting it; instead, the user is required to remember to save each time information is added. With all the noise and commotion of a KC-135 flight, it is understandable that the subjects did not remember to save the data.

There is also very little data in the address book. One subject stated that most of the time was spent attempting to enter a name correctly. From the questionnaire responses it seems that this subject did not remember the procedure for correcting recognition errors, and instead, entered the name multiple times. Another subject did not have time to try the address book task. Only one remaining subject succeeded in starting a new address book entry, and this subject only entered four out of the 11 information fields. Based on this subject's questionnaire, attempts to correct handwriting recognition errors were indeed made, but even after these attempts, all four fields contained recognition errors.

The following results come solely from the questionnaire data.

3.1 Ratings. Table 2 shows the questionnaire results for each subject and averages over the three subjects for each of the nine rating questions. Possible responses

ranged from 1 (Completely Unacceptable) to 7 (Completely Acceptable). A rating of 4 was considered the border between acceptable and unacceptable.

TABLE 2. Questionnaire Data

Question	S1	S2	S3	Av. Rating
1. Size with respect to portability	7	7	7	7.0
2. Ease of temporary stowage	6	7	6	6.3
3. Handwriting in μ-G	4	N/A	4	4.0
4. Use of Newton's stylus in μ-G	5	6	6	5.7
5. Glare off the screen	6	4	4	4.7
6. Overall readability	4	4	4	4.0
7. Finding an orientation with a minimum amount of glare	6	5	4	5.0
8. Accuracy of handwriting recognition	2	N/A	1	1.5
9. Correcting Newton's handwriting recognition errors	2	N/A	4	3.0

Newton rated highest on portability and ease of temporary stowage in microgravity and lowest on accuracy of handwriting recognition and ease of correcting recognition errors. The only issue unique to the microgravity environment that received a borderline rating of 4 was handwriting in microgravity. Glare proved to be a problem. The low ratings on glare and attempts to reduce glare are probably significantly responsible for the borderline rating for overall readability in question six, although the lack of backlighting in LCD screens make them difficult to read in general.

Question 10 asked the subjects to comment on how much they needed to restrain themselves - and how they did it - in order to perform the Newton tasks. No specific means of restraint was provided nor suggested in order to determine whether one may be necessary on orbit. All subjects commented that restraint was an issue. One subject first attempted to tuck her feet underneath a cargo strap, simulating short duration foot restraints, but then stated that her body was still too mobile. This subject then found that hooking her feet underneath a plane seat armrest and leaning back against the side of the plane gave her enough restraint and support to use Newton effectively. Another subject also combined two means of restraint. This subject hooked her toes around something on the floor and leaned into a piece of hardware. Again, a makeshift foot restraint was combined with a means of stabilizing the entire body. The third subject had difficulty finding any adequate restraint.

3.2 Comments. Space was provided on the questionnaire for subjects to comment on anything else regarding the hardware or the tasks. Readability came up in each subject's comments. Glare and low visibility of the LCD were problems all subjects encountered. One subject suggested that a small, clip-on light would enhance visibility. Other comments were that the Newton was comfortable, easy to hold, and easy to use and that the handwriting recognition was aggravatingly poor.

4.0 DISCUSSION AND CONCLUSIONS

With Newton's problematic handwriting recognition system, the stylus may be best used as a simple pointing device. In fact, the subjects rated use of the stylus in microgravity relatively highly in question four. Even with this limitation, crewmembers could perform

any task with the PDA that they would accomplish with a mouse and a computer. Perhaps the crewmember would still enter notes into the PDA by hand, but they would be saved as written; the handwriting recognition capability could be disabled.

The borderline rating received for handwriting in microgravity may be mostly a result of the lack of specified restraint. Only one subject was able to find a comfortable means of restraint right away; the other two subjects tried various positions, and one of them never found adequate restraint. Figure 1 shows a subject attempting to restrain the upper body while simultaneously using the PDA. Interestingly, this third subject stated that the lack of adequate restraint, "...affected my ability to get comfortable with it [the Newton]." Perhaps it will be important to train crewmembers to find a comfortable, stable position if they are planning to work with the logbook for more than a few minutes. Indeed, crewmembers will be able to perform logbook tasks in any type of restraint, but it may be possible to increase a crewmember's acceptance of using the logbook on a regular basis if a standard, comfortable restrained position may be suggested. If future evaluations echo the finding that a lack of adequate restraint can affect one's ability to use a PDA in microgravity, the current expectation that ISS crewmembers will be able to turn on their PDAs and make notes whenever and wherever necessary may not be accurate.

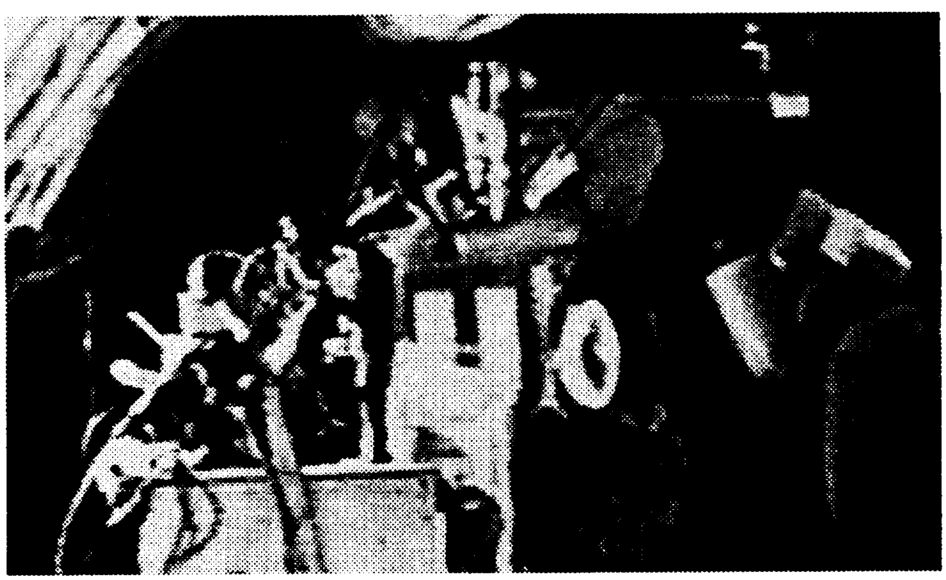

Figure 1. Subject attempts to restrain self by wrapping an arm around a camera stand. The subject is holding the Newton in his left hand.

Periodically, during all three KC-135 flights, the subjects experienced negative Gs. It is quite possible that pulling negative Gs may have affected the perceived usability of the Newton. It is easy to see how ratings on issues such as restraint and handwriting would be easily affected by suddenly being pulled up toward the ceiling of the plane.

Many issues requiring further investigation were either directly addressed by or simply brought to light in this initial usability testing. Some are specific to the microgravity environment, and some are PDA issues that are relevant in both 1-G and microgravity settings. Table 3 separates the issues that require further testing into these two categories. The most important issues resulting directly from this study are handwriting recognition problems and restraint problems. Of course, with further work, many as of yet unidentified issues will be discovered.

TABLE 3. Issues Requiring Further Evaluation

General Issues	Microgravity Issues
Poor handwriting recognition capability	Adequate restraint
Screen glare	Hardware issues (e.g., battery changeout)
Readability/visibility of LCD screen	Comfort and hand fatigue in long duration usage

5.0 RECOMMENDATIONS FOR FUTURE WORK

The results of this testing suggest that being adequately restrained affected how comfortable the subject felt using the stylus for either handwriting or simple tapping. Future work should examine the relationship between restraint and stylus usage. One possible means of doing this would be to provide the subject with at least two different restraint systems and to have the subject perform the same tasks with each restraints. Such a procedure would also help separate results related to the actual hardware from the microgravity issues listed in Table 3. The tasks would be representative of tasks that ISS crewmembers are expected to perform with the hand-held logbook. For example, the subjects would be asked to check certain boxes in a checklist or mark a specific point on a rating scale. It is expected that subjects will perform more accurately given a more stable restraint, but it is hoped that performance improvement will level off at a given level of restraint. Conducting ground testing prior to microgravity testing would also allow for a general assessment of stylus accuracy in microgravity versus 1-G.

Many of the problems experienced with restraint and handwriting may be related to pulling negative Gs during the KC-135 flights, as stated in section 4.0. Manifesting an experiment onboard the Orbiter would allow for a thorough investigation of necessary restraint in a pure microgravity environment. An investigation into the issue of comfort and hand fatigue in long duration usage (Table 3) would also be possible; the short bursts of microgravity aboard the KC-135 do not allow for fatigue evaluations.

It is recommended that further usability testing utilize the current hand-held electronic logbook prototype: the Norand Pen*key Model #6300. If the Newton should undergo

further testing as a prototype, it is recommended that the handwriting recognition capability be de-activated, since it is expected that the actual HRF logbook will have far better recognition capabilities. In this manner, the issue of handwriting on a PDA in microgravity may be addressed without introducing frustration toward Newton's limited capabilities and having this frustration affect the subjects' ratings of the hardware.

Lastly, it is important to remember that this evaluation was integrated into a set of KC-135 flights that were already very busy. Unfortunately, this experiment did not receive the attention it should have, since subjects were busy performing the primary ergonomic evaluation. Future testing should encompass ground and microgravity portions in order to truly identify issues unique to the microgravity environment, but this study helped to identify important logbook usability issues.

6.0 REFERENCES

Human Research Facility Functional Requirements Document. (LS-71001, August 31, 1995). Houston, TX: Human Research Facility Project Office.

Human Research Facility Level 1 Science and Technical Requirements. Document, Draft, May 25, 1995.

APPENDIX

Subjective Questionnaire

Questionnaire - KC-135
Usability Evaluation of HRF Prototype PDA/Newton

1	2	3	4	5	6	7
Completely Unacceptable			**Borderline**			**Completely Acceptable**

For the following questions, provide a response on the answer sheet.

A. Acceptability of Newton in terms of:

1. Size with respect to portability
2. Ease of temporary stowage
3. Handwriting in 0-G
4. Use of Newton's pen in 0-G
5. Glare off the screen
6. Overall readability
7. Finding an orientation with a minimum amount of glare
8. Accuracy of handwriting recognition
9. Correcting Newton's handwriting recognition errors.

B. General:

10. Comment on how much you had to restrain yourself (and how you did it) in order to perform the Newton tasks.

---

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______

10. ____

____

GENERAL COMMENTS:

____

____

____

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
April 1996

3. REPORT TYPE AND DATES COVERED
NASA Contractor Report

4. TITLE AND SUBTITLE
Initial Usability Testing of a Hand-held Electronic Log book Prototype for the Human Research Facility

5. FUNDING NUMBERS
NAS9-18800

6. AUTHOR(S)
A. H. Berman and M. Whitmore / Lockheed-Martin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA CR-199849

11. SUPPLEMENTARY NOTES
NASA Technical Monitors associated with this project were F. Mount and B. Woolford/SP34.

12a. DISTRIBUTION / AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

The Apple Newton MessagePad 110 was flown aboard the KC-135 reduced gravity aircraft for microgravity usability testing. The Newton served as the initial hand-held electronic logbook prototype for the International Space Station (ISS) Human Research Facility (HRF). Subjects performed three different tasks with the Newton: 1) using the stylus to tap on different sections of the screen in order to launch an application and to select options within it; 2) using the stylus to write, and; 3) correcting handwriting recognition errors in a handwriting-intensive application. Subjects rated handwriting in microgravity "Borderline" and had great difficulties finding a way in which to adequately restrain themselves at the lower body in order to have their hands free for the Newton. Handwriting recognition was rated "Unacceptable," but this issue is hardware-related and not a function of the microgravity environment. It is suggested that the restraint and handwriting issues are related and require further research with the current Hand-held Electronic Logbook Prototype: the Norand Pen key Model #6300.

14. SUBJECT TERMS
Usability, PDA, Stylus, Handwriting recognition

15. NUMBER OF PAGES
8

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT